FOREST HEALTH PROTECTION
South Sierra Shared Service Area
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To: Karen Caldwell, District Ranger, Summit Ranger District, Stanislaus National Forest

Subject: Evaluation of Fire-Injured Trees in the Lily Project Thinning and Prescribed Underburn, Summit Ranger District, Stanislaus National Forest

At the request of John Nelson, District Planner, I conducted an evaluation of post-fire tree injury and general stand health in a unit of the Lily thinning and prescribed burn project on the Summit Ranger District, Stanislaus National Forest, on October 20th and December 1st, 2008. The objective of this visit was to identify causal agents likely contributing to large-diameter ponderosa pine mortality. This type of tree mortality has also occurred in several recent prescribed underburns on the District. This report summarizes: 1) agents influencing mortality in the Lily Project area, 2) additional observations made throughout forests in the southern Sierra-Nevada Mountains regarding post-fire mortality, and 3) potential management options available to reduce the risk of large-diameter conifer mortality in Rx underburn treatments.

The Lily project area (Appendix A) was commercially thinned from below in the summer of 2001 to residual basal area targets of 150 feet^2/acre while retaining at least 50% canopy cover. However, the individual unit in which large-diameter tree mortality occurred was designated Northern Goshawk and Spotted Owl Habitat and only occasional ladder fuels exceeding 4 inches at DBH were removed. Slash created during this activity was "lopped and scattered" as the tops, limbs, and other fine fuels were evenly distributed across the stand with fuel heights not to exceed 18 inches above the ground. An underburn was conducted in late October 2005 during dry conditions that promoted "spotting outside the burn unit" (pers comm., J. Nelson, Summit Ranger District Planner, 11/6/08) which may have exposed conifers to high surface fire intensities.

Observations

Stand conditions were surveyed throughout an 8 acre unit of the Lily project area where large diameter trees with fading crowns were identified by District personnel. Stands were multistoried with two distinct canopy layers of mature trees and an understory of immature saplings and pole-sized trees (Figure 1). The upper canopy trees averaged 40" DBH (range 30-80") consisting of 85% ponderosa pine (*Pinus ponderosa*), 10% sugar pine (*Pinus lambertiana*), and 5% white fir (*Abies concolor*). The lower canopy layer trees averaged 15" DBH (range 10-30") consisting of 50% white fir and 50% incense cedar (*Calocedrus decurrens*). The immature understory poles were <10" DBH and grouped in several dense thickets. Median stand density was 280 ft^2 (range 200-400 ft^2) of basal area/acre.

Figure 1. Diameter ranges of the three canopy layers present in Lily unit surveyed

The upper canopy layers did not receive any apparent fire-related crown kill while understory poles had an average of 75% live crown length kill (range 25-100%). Vertical bole char for trees in the upper canopy layers averaged 4 feet in height (range 0-15 feet), encompassing at least 50% of the bole circumference and was commonly moderate or high in severity (as defined in Ryan 1982) (Figures 2 & 3). Vertical bole char in the understory poles typically encompassed the entire height and bole circumference as groups of poles were completely consumed in the underburn (Figures 1 & 7).

Figures 2 & 3. Typical bole char severity and char height associated with the large-diameter ponderosa pine mortality in Lily project area

Bark beetles were associated with the mortality that occurred in 4 of the 20 (20%) upper canopy layer ponderosa pines (53-67" DBH). Two trees were currently fading and had western pine beetle (*Dendroctonus brevicomis*) (WPB) callow adults present during the 12/1/08 visit (Figures 4 & 5). The other two trees faded earlier in summer 2008 and had characteristic western pine beetle egg and larval galleries. Bole char in these trees averaged ≈ 5 feet in height and covered an average 75% (range 50-100%) of the bole circumference with moderate or high severity bole char ratings. These bole char ratings corresponded to necrotic cambial tissue in all the areas I surveyed that had high severity bark char and the majority (≈ 75%) of areas with moderate severity bark char. Red turpentine (*Dendroctonus valens*) (RTB) and wood boring beetles (Family: Cerambycidae and Buprestidae) were associated with all the recent mortality. Red turpentine beetles also attacked 15/24 (62.5%) of the live ponderosa and sugar pines in the upper canopy layer, generally targeting areas with high-severity bark char.

Figure 4. Pitch tubes after western pine beetle attack

Figure 5. Fading crowns of dying ponderosa pines

Increment cores from eight trees with faded, fading or healthy green crowns were analyzed in the field to determine growth rates. In general, all samples indicated a decreased growth rate starting around 1990 and only 1 tree with a healthy green crown in the lower canopy had evidence of increased growth after the thinning treatment.

Post-fire mortality of larger diameter trees has recently occurred (2005-2008) in multiple locations in the southern Sierra Nevada Range. Similar patterns have emerged from some of the trees in recent wildfires and Rx underburns including: bark beetles were often associated with mortality, many trees had low bole char heights, low crown kill percentages, and moderate or high bark char severity at ground level. Specifically, after the 2004 Power Fire on the Eldorado National Forest, western pine beetle-associated mortality has occurred in fire-injured ponderosa pines from 2006-2008. After this fire, mountain pine beetles were also found in the majority of dead and fire-injured sugar pines. After the 2002 McNally Fire, on the Sequoia National Forest, Jeffrey pine beetle (*Dendroctonus jeffreyi*)-associated mortality occurred in multiple groups of fire-injured trees.

Discussion and Recommendations

Mortality observed in the Lily project unit occurred after successful western pine beetle attacks in large diameter pines stressed by multiple factors including:

- Fire-caused cambial injury
- Multiple years of below average precipitation
- Overstocked stand conditions

This mortality occurred when western pine beetle populations were generally considered endemic (as defined in Sartwell & Stevens 1975), as little mortality was observed in the 2008 Aerial Detection Flights (Appendix A) and no bark beetle attacks were observed on any ponderosa pines in adjacent stands. Under these conditions, western pine beetles typically attack larger diameter trees that are physiologically stressed. RTB attacks were associated with all of the large-diameter tree mortality. Presence of RTB attacks has been correlated with an increase in the probability of mortality for fire-injured trees (Smith and Cluck 2007) but it is not known whether this beetle contributes to, or is just associated with other factors causing, conifer mortality. Regardless, presence RTB attack alone does not indicate eminent tree mortality.

Cambium kill severely stressed the large diameter pines in the Lily underburn. This injury appeared to be the primary catalyst in triggering the bark beetle attacks and subsequent tree mortality. Mortality of other large diameter pines with high levels of cambium injury will likely occur over the next few years in this unit.

The District has experienced below average precipitation (Figure 6) in 8 of the previous 10 years. These drought conditions have likely interacted with overstocked stand conditions (median basal area was 280 ft^2/acre) and the fire-injuries to reduce the health and vigor of trees in the surveyed stand. This general stress was exemplified in the

annual tree rings as no noticeable increase in secondary, basal area growth occurred after the thinning treatment.

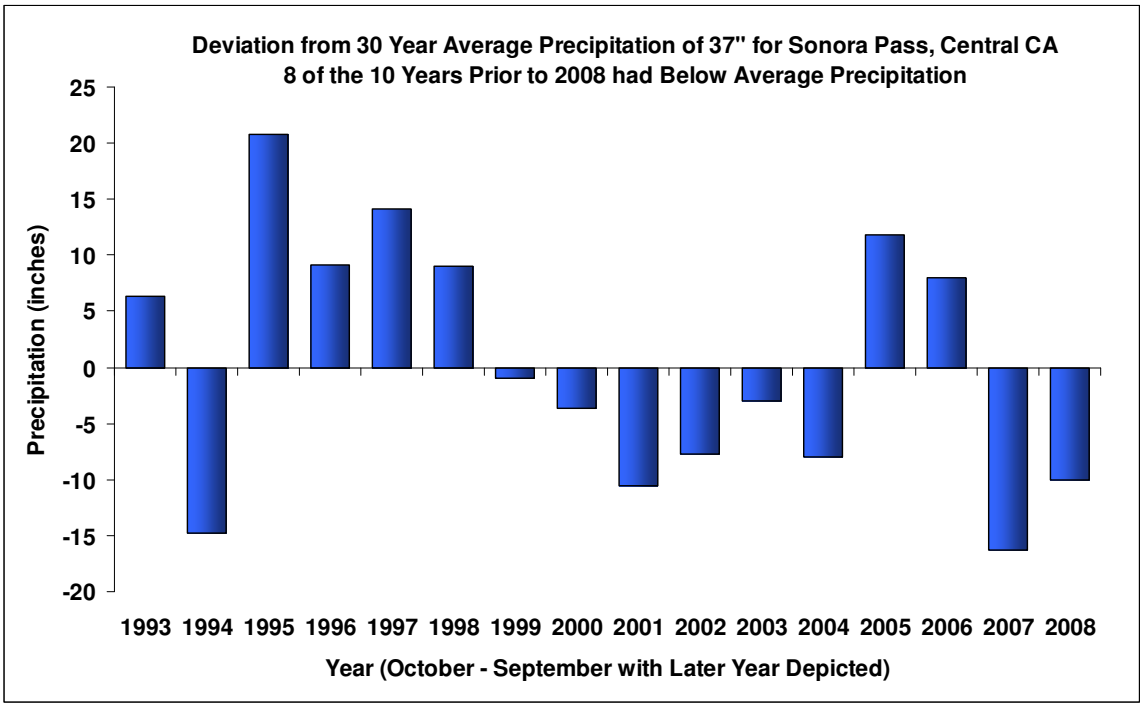

Figure 6. Precipitation data for Sonora Pass obtained from Natural Resource Conservation Service SNOTEL weather station at: http://www.ca.nrcs.usda.gov/snow/data/historic.html

Of the contributing factors (fire-injury, bark beetle attack, drought and competition) that interacted to cause tree mortality in the Lily project area, fire-injury and competition are the only ones that are practical to manipulate with management activities. To effectively reduce large-diameter tree mortality in future thinning and Rx underburn projects, implementation of both the following options should be considered.

Management Options:

Option 1 – Reduce Stocking

Excessive competition for limited soil moisture can lead to low oleoresin exudation pressure, which increases ponderosa pine susceptibility to western pine beetle-caused mortality when attacked (Vite & Wood, 1962). Competition can be reduced by thinning to lower residual stand densities. The unit containing the mortality had a median basal area of 280 ft^2/acre. Thinning to or below 60% of maximum Stand Density Index (SDI) or reducing basal area to less than 80% of "normal" for a given site can reduce inter-tree competition and the risk of bark beetle-related mortality. These targets are consistent with direction given by the previous Regional Forester that recommended designing treatments "to ensure that this level will not be reached again for at least 20 years after

thinning" (Regional Forester letter, "Conifer Forest Density Management for Multiple Objectives", July 14, 2004).

In many instances, the large diameter pines in the affected unit were surrounded by high densities of smaller trees (Figure 7). Where density reduction to the recommended targets cannot be achieved at the stand-level, removing vegetation around large diameter trees can reduce fire-injury (by removing ladder fuels) and local competition for water and nutrients necessary to produce defensive oleoresin. Although, limited information exists regarding the efficacy of radial thinning treatments for large diameter ponderosa pines (Kolb et al. 2007), R5 FHP personnel in the Northeastern California Shared Service Area have measured growth increases after radial thinning treatments. These treatments removed all conifers <12" DBH from within a 30-foot radius around yellow pines averaging ≈ 30 inches DBH. However, this treatment did not always result in a low enough stocking level to effectively reduce competition. Greater increases in growth response were achieved in the same project where basal area was significantly reduced at the stand-level. As DBH values of large diameter trees commonly exceeded 50 and 60 inches in the Lily unit surveyed, it is recommended that all vegetation within at least a 50-foot radius around high-value trees be removed. In situations where other high-value trees are within this 50-foot radius, it is recommended to reduce local basal area below the previously discussed stand-level targets.

Figure 7. Tree density surrounding a large diameter pine in Lily project area

Option 2 – Reduce Fine Fuel and Duff Loadings with Tree Raking

Basal fire injury is most severe when excessive litter and duff fuel layers smolder over extended time periods exposing outer and inner bark layers to intensive radiant heat. Fire exclusion policies over the past 100+ years has led to litter and duff depths that often exceed the historic range of variability for ponderosa pine forests (Hood et al. 2007). A potential tool to mitigate these increases is tree raking. Forest Health Protection staff in the Northeastern California Shared Service Area are collaborating with the Rocky Mountain Research Station Fire Science Laboratory to monitor the effects of tree raking on post-Rx fire conifer injury and mortality on the Lassen National Forest and in Lassen Volcanic National Park. Material was raked to mineral soil and dispersed evenly to avoid creating fuels mounds and reduce root-injury during the underburns. Post-fire data from this study indicates that raking around large diameter ponderosa pines can be an effective tool in protecting trees from cambium injury and red turpentine beetle attack. The average amount of time required to rake the duff and litter away from an individual tree (out to 2' and down to mineral soil) was 16 minutes/person (more time was needed where brush was present). Raking duff and litter alone in this manner did not result in tree mortality (Hood et al. 2007). This type of treatment will likely reduce the risk of mortality for high-value trees that the District wishes to protect.

I would like to thank John Nelson for assistance in data collection and providing photographs for this report. Feel free to contact the South Sierra Shared Service Area staff with additional questions.

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Attachments: Hood, S. et al. (2007) & FS Brief 31 (2009)

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Appendix A

Lily Project Location with 2008 Aerial Survey Results
Summit RD, Stanislaus NF